IP layer mobility operation and beyond

The Second Asia Future Internet School

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Topics

- Mobile IPv6 experiment toward the global operation
- Mobility technology application beyond the infrastructure-based mobility

Mobile IPv6

- Network layer (Layer 3) mobility protocol
  - On top of IPv6
  - Backward compatibility
  - Less impact to the existing infrastructure
  - Several extensions, e.g.
    - Network mobility
    - Dual-stack support

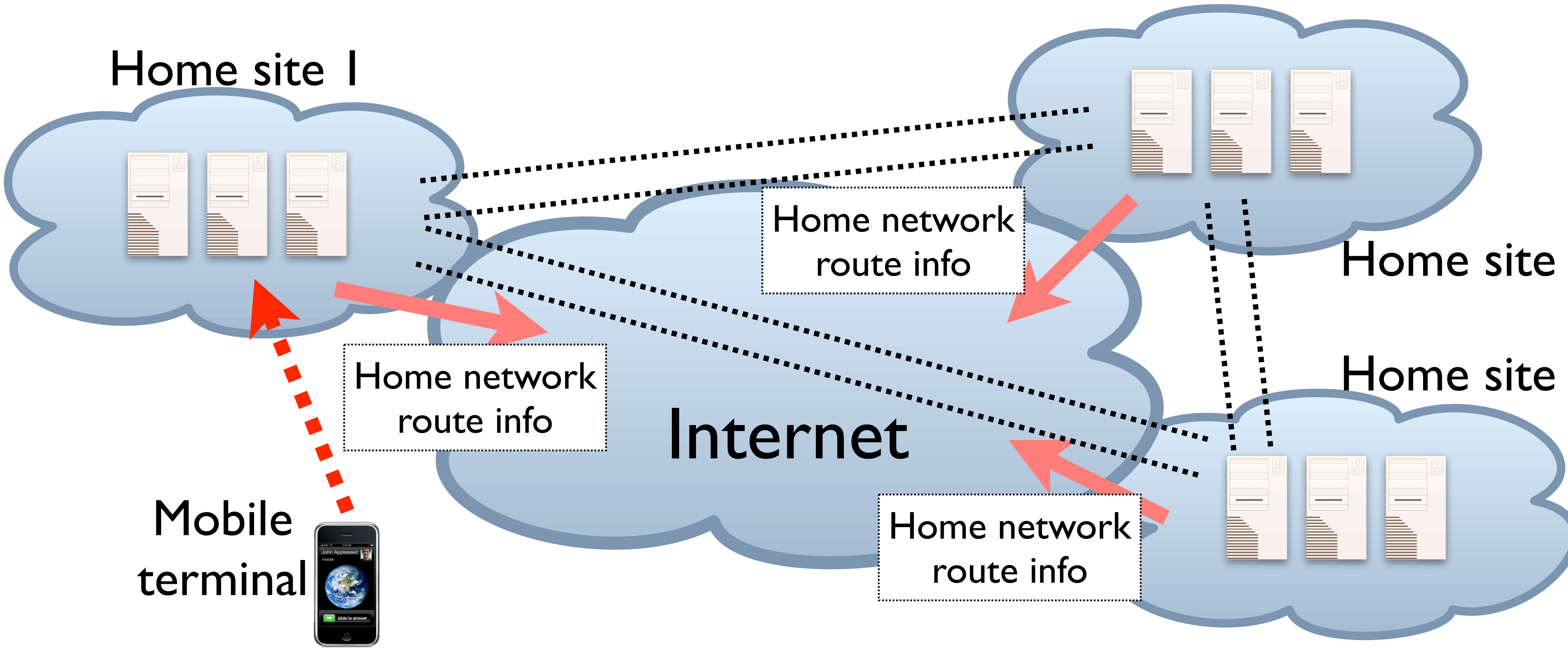
Issues

- Mobile IPv6 is a kind of a tunnel based protocol
  - Single point of failure of the tunnel server (home agent)
  - Redundant path (due to location of mobile nodes and their home agents)

Global operation

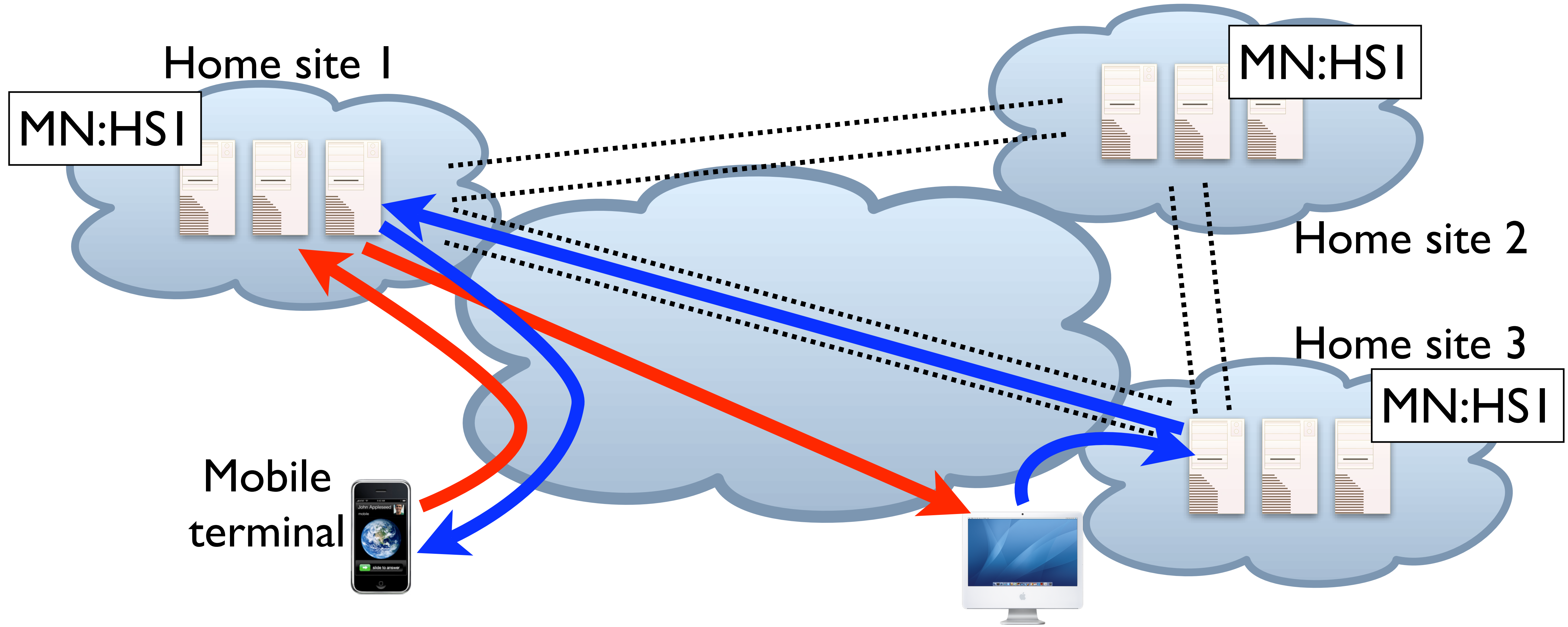
- Single point of failure
  - Locate several home agents around the world
- Redundant path
  - Use nearest home agent

Global HAHA Concept



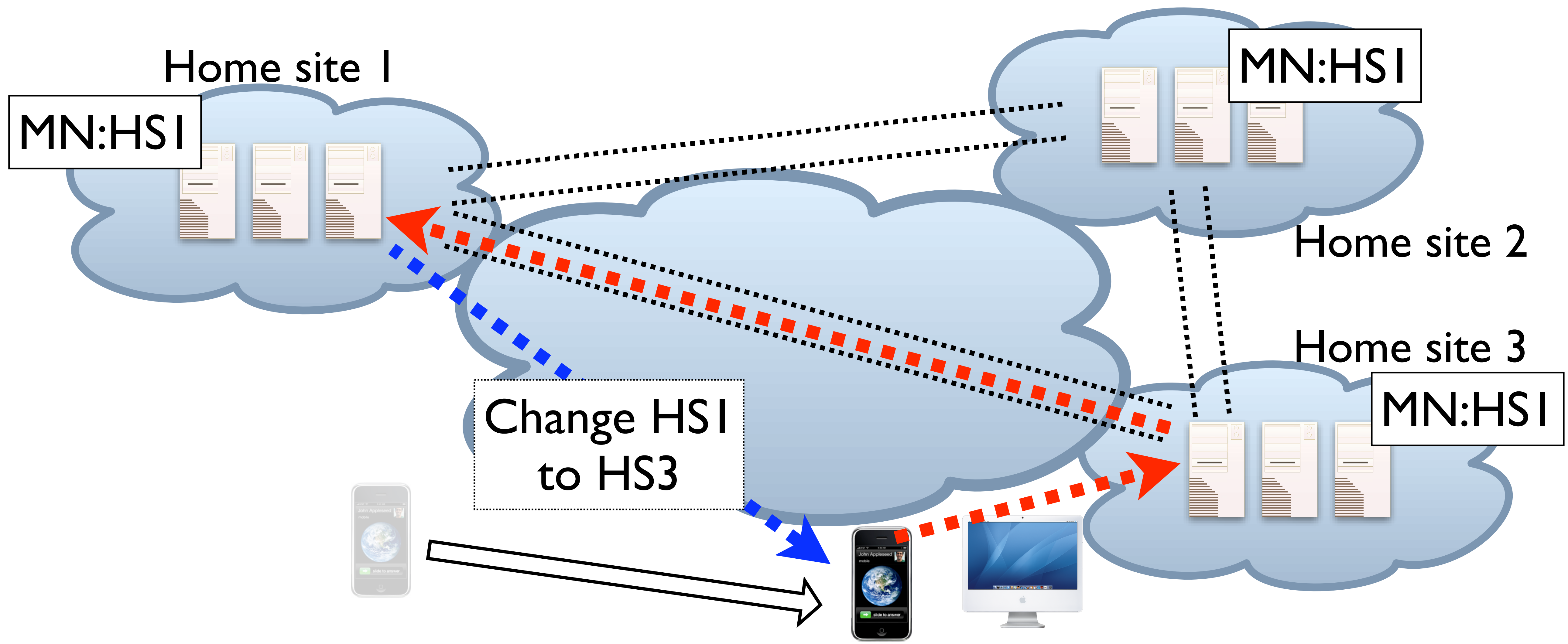
- The same route information is advertised to the global Internet
- Nearest agents will serve mobility requests

How it works



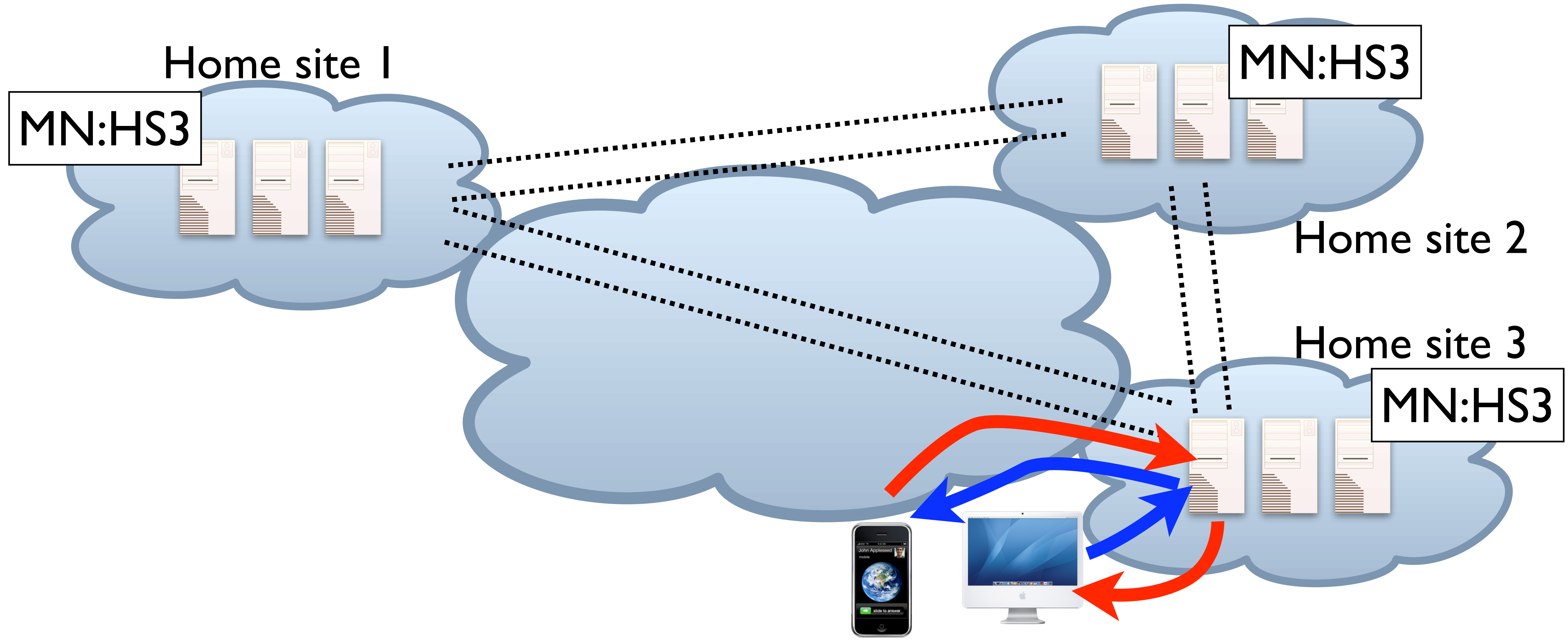
- Forward traffic goes to the nearest HA and forwarded to CN
- Reverse traffic goes to the nearest HA (to CN) and tunneled to the HA nearest to MN using the HAHA network

How it works



- Home agent at home site 1 notices **MN is now moved to home site 3**
- Home agent **sends a migration message to MN**

How it works



- Forward traffic is now terminated by HS3
- Reverse traffic is also forwarded by HS3

SHISA

- IPv6 mobility development/research infrastructure for BSD operating systems
- Supported RFCs
  - Mobile IPv6 (RFC3775, 3776), NEMO BS (RFC3946), Multiple CoA Registration, IPv4 traversal [experimental]
- User space protocol signal processing
  - Easy to support new protocols
- Kernel level packet forwarding
  - Keep forwarding performance

Protocol Verification

- We believe rough consensus and working code, don’t we?
    - Verify the protocol by extending SHISA framework
    - Using a real testbed

Global Operation Implementation Design for SHISA

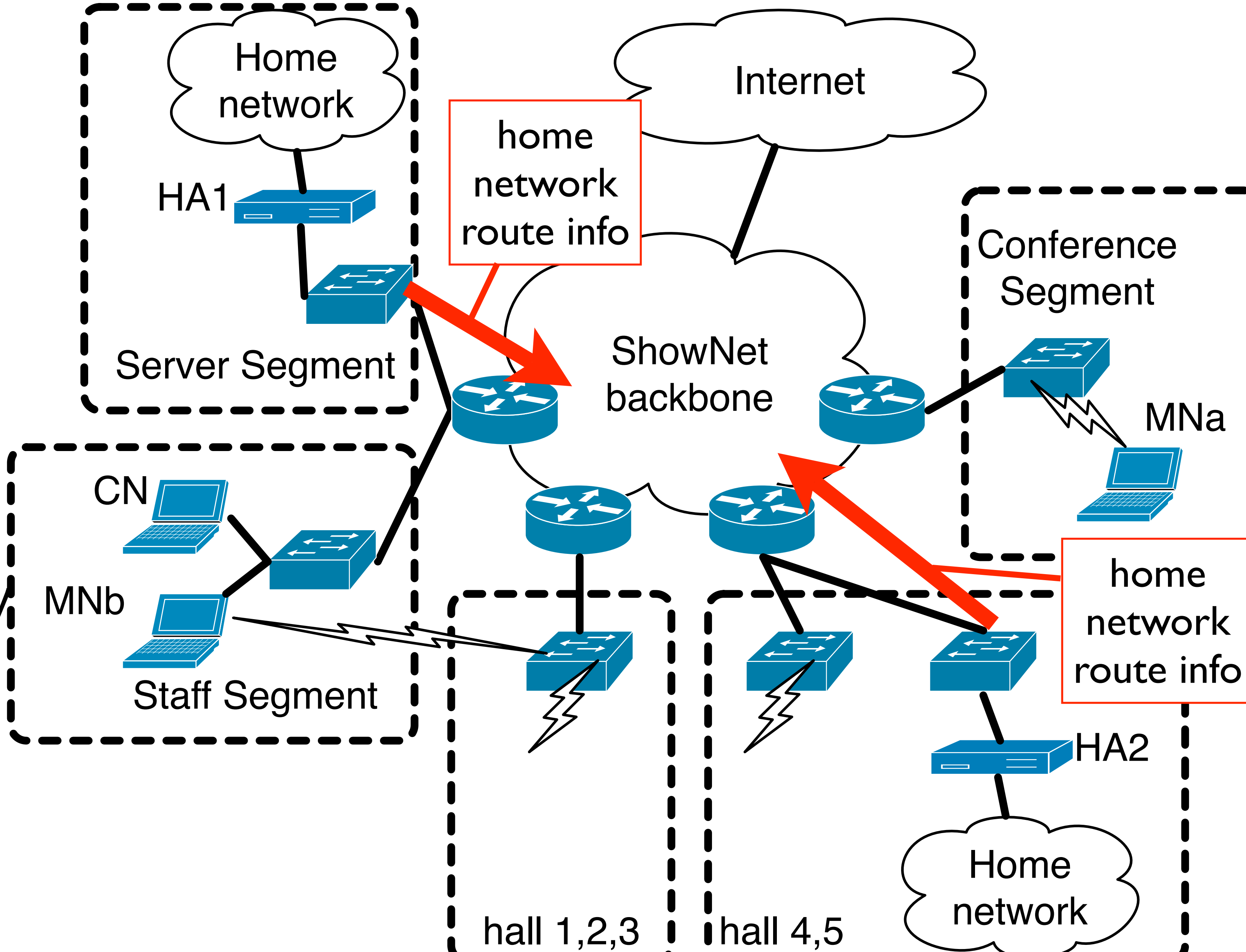
- Only small modification is required
  1. HA to HA tunnels are established before operation using the generic IP tunnel mechanism
  2. Binding cache information is copied using a newly defined Mobility Header signal message
  3. HA switch message is sent using a newly defined Mobility Header signal message
  4. Packet forwarding from HA to HA is implemented using the standard host route mechanism

Testbed

- Interop Tokyo 2008
  - One of the biggest exhibition/conference for network equipment/service vendors

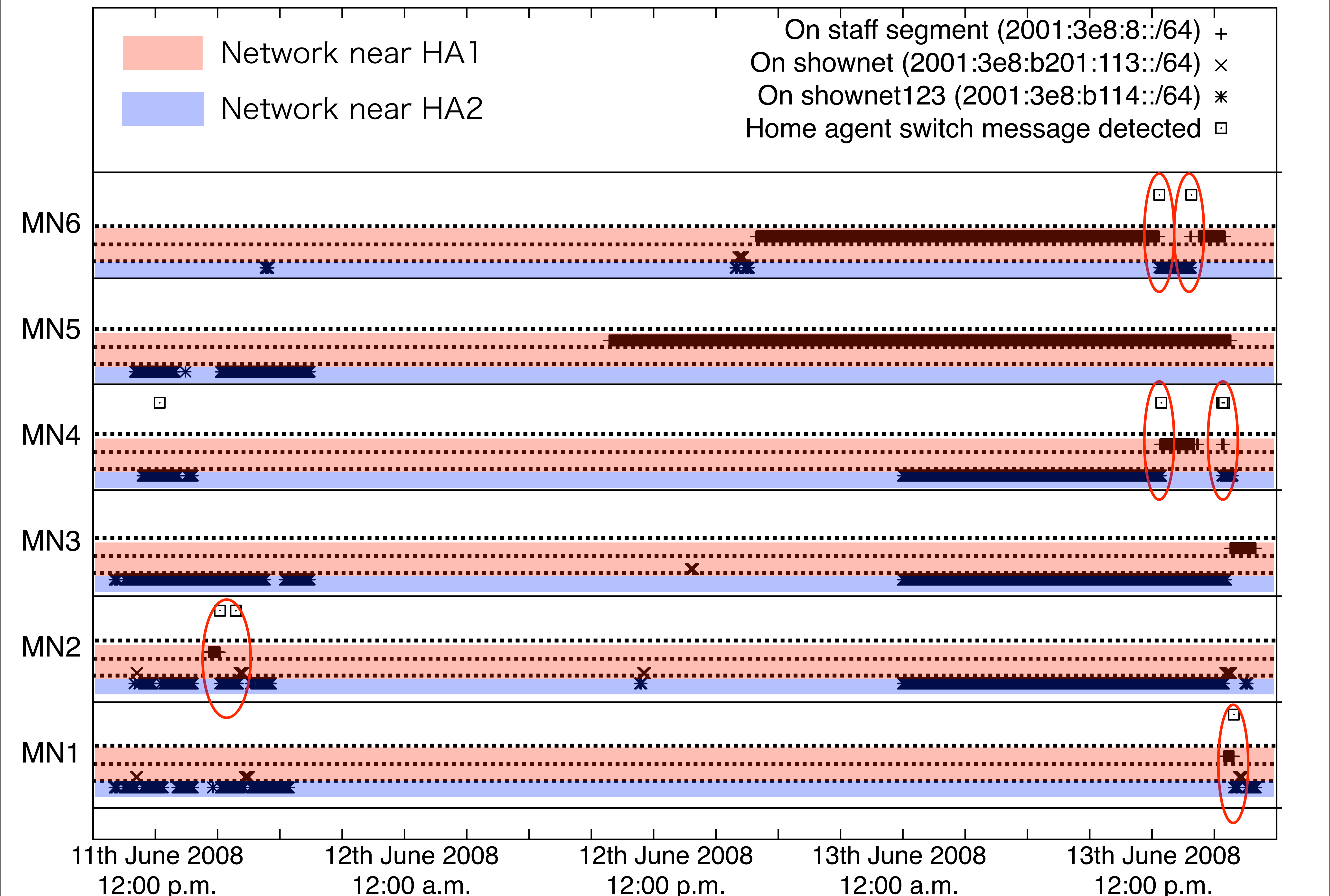
Topology

- 2 home agents
- 4 foreign networks
- Home network route information is advertised from two different locations by OSPFv3



Verification Items

- Check if a MN registers to the nearest HA when booting
- Check if a MN re-registers to a nearer HA when it moves to the network close to the HA
- Check if performance is improved by changing HA

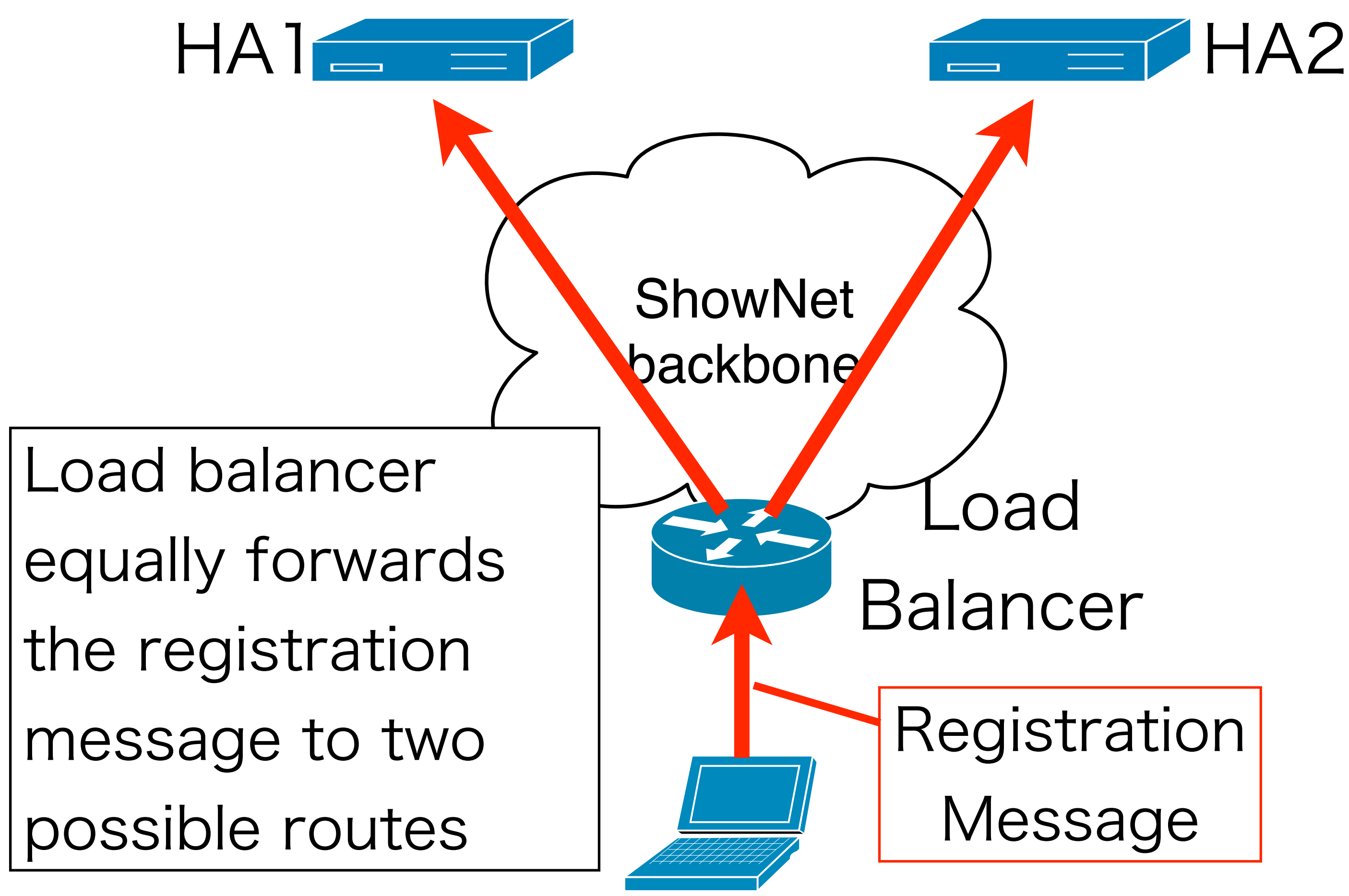

Network near HA1
Network near HA2
On staff segment (2001:3e8:8::/64) +
On shownet (2001:3e8:b201:113::/64) ×
On shownet123 (2001:3e8:b114::/64) ✳
Home agent switch message detected ⊡
MN6
MN5
MN4
MN3
MN2
MN1
11th June 2008 12:00 p.m.
12th June 2008 12:00 a.m.
12th June 2008 12:00 p.m.
13th June 2008 12:00 a.m.
13th June 2008 12:00 p.m.

Results

- MN could register to the nearest HA when booting
- MN could re-register to nearer HA if necessary when it moves
- We couldn't verify performance enhancement
  - Because the network scale was too small to check performance difference
  - We need larger scale testbed to confirm the enhancement

Other findings

- Ping-pong registration problem
    - We relied on the underlying event network for packet routing
    - A load balancer sometimes works as we do not expect



1.Mobile layer need to coordinate with underlaying routing layer
2.Load balancer must have knowledge of Mobility protocols

Beyond the Infrastructure based mobility

Background

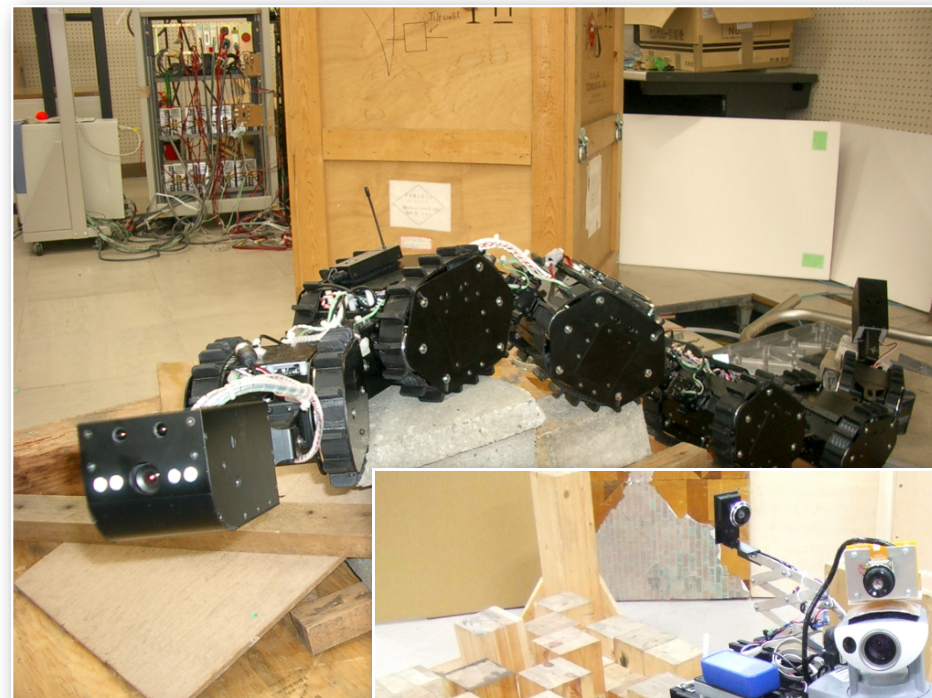
- Increasing threats of natural disasters in urbanized cities
- Increasing threats of artificial disasters, like terrorism in crowded parts of a city
- High risk to get into collapsed structures

Current Status

- Remote rescue operation using robots is intensively being researched
  - e.g. http://www.rescuesystem.org
- Investigation of disaster areas using a robot controlled by a human operator

Ex. Crawler Robot

- A robot with many crawlers
- Each crawler is connected by a joint with high degree of freedom
- Can get over obstacles in disaster areas



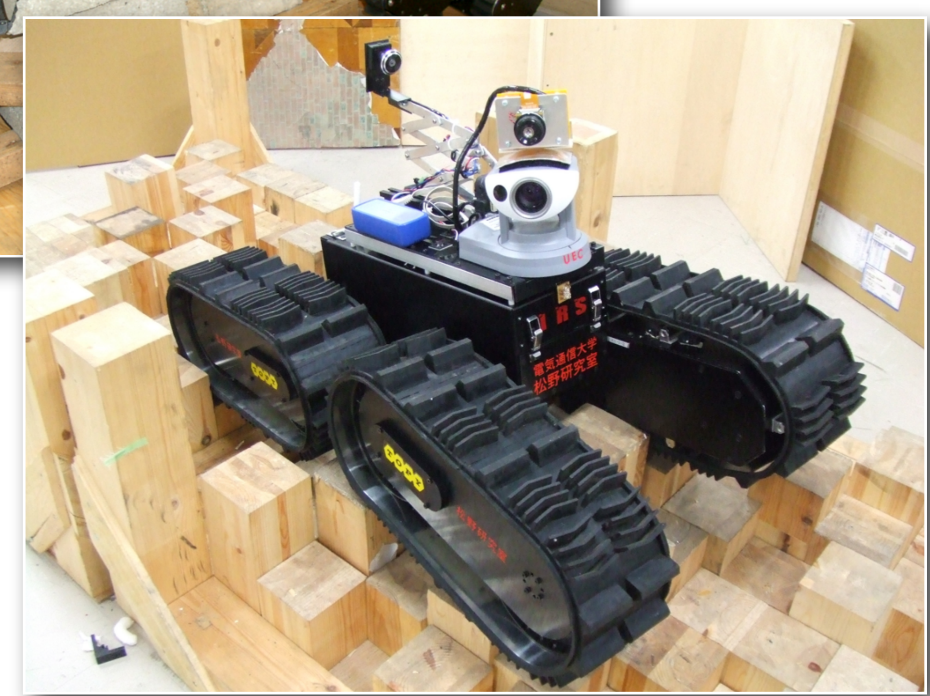


Photo by Matsuno Laboratory at the University of Electro-Communications, Japan

Problems

- Most of the robots are designed to be controlled by a simple remote control method (e.g. with a wired remote)
  - The range that the robot can move around is limited by the range of the remote
  - An operator must get into the disaster area with the robot to control it, that may cause a secondary disaster

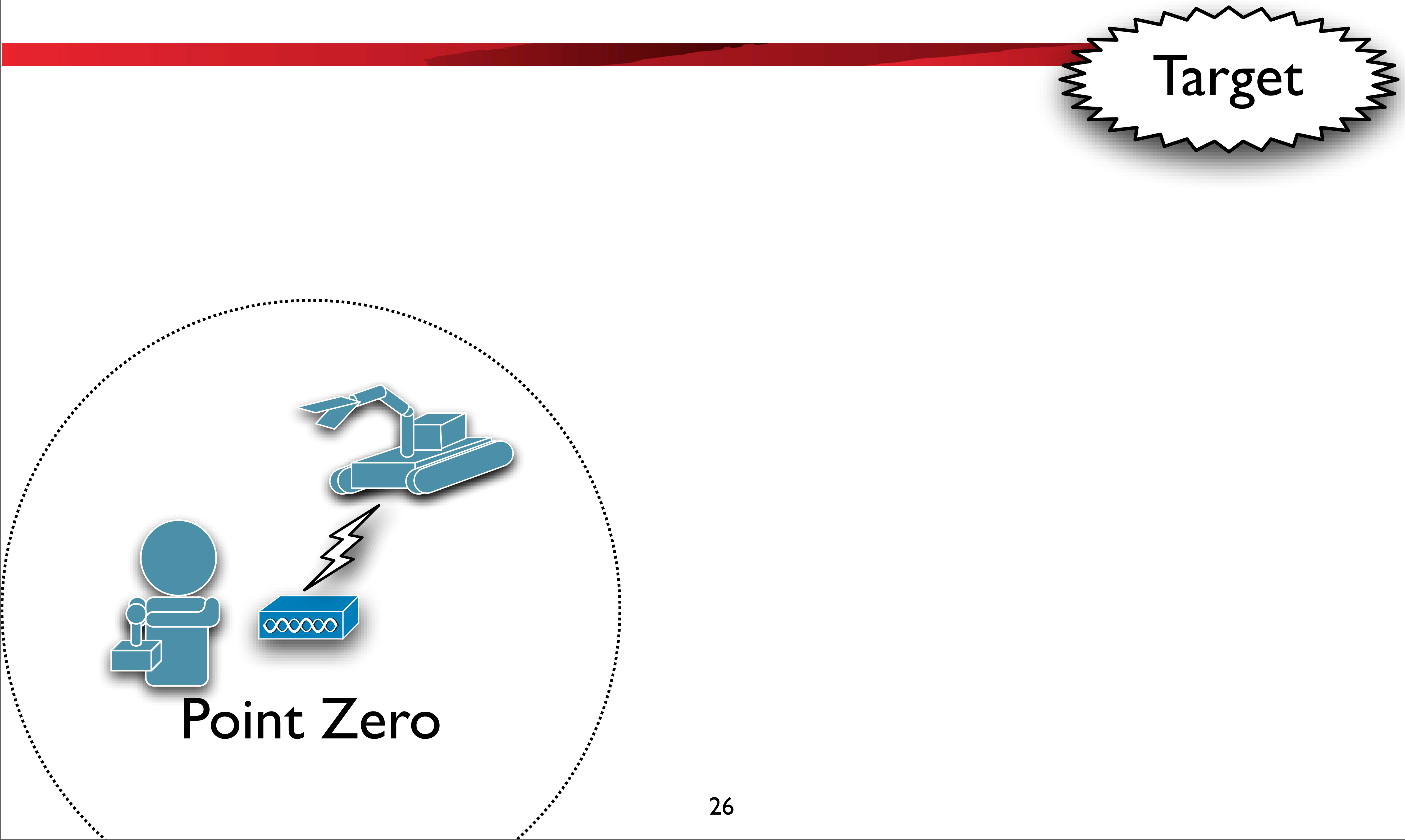
Assumed Environment

- Inside buildings (e.g. Subway stations, underground malls)
- Large searching area
- No communication infrastructure
- Unstable communication environment

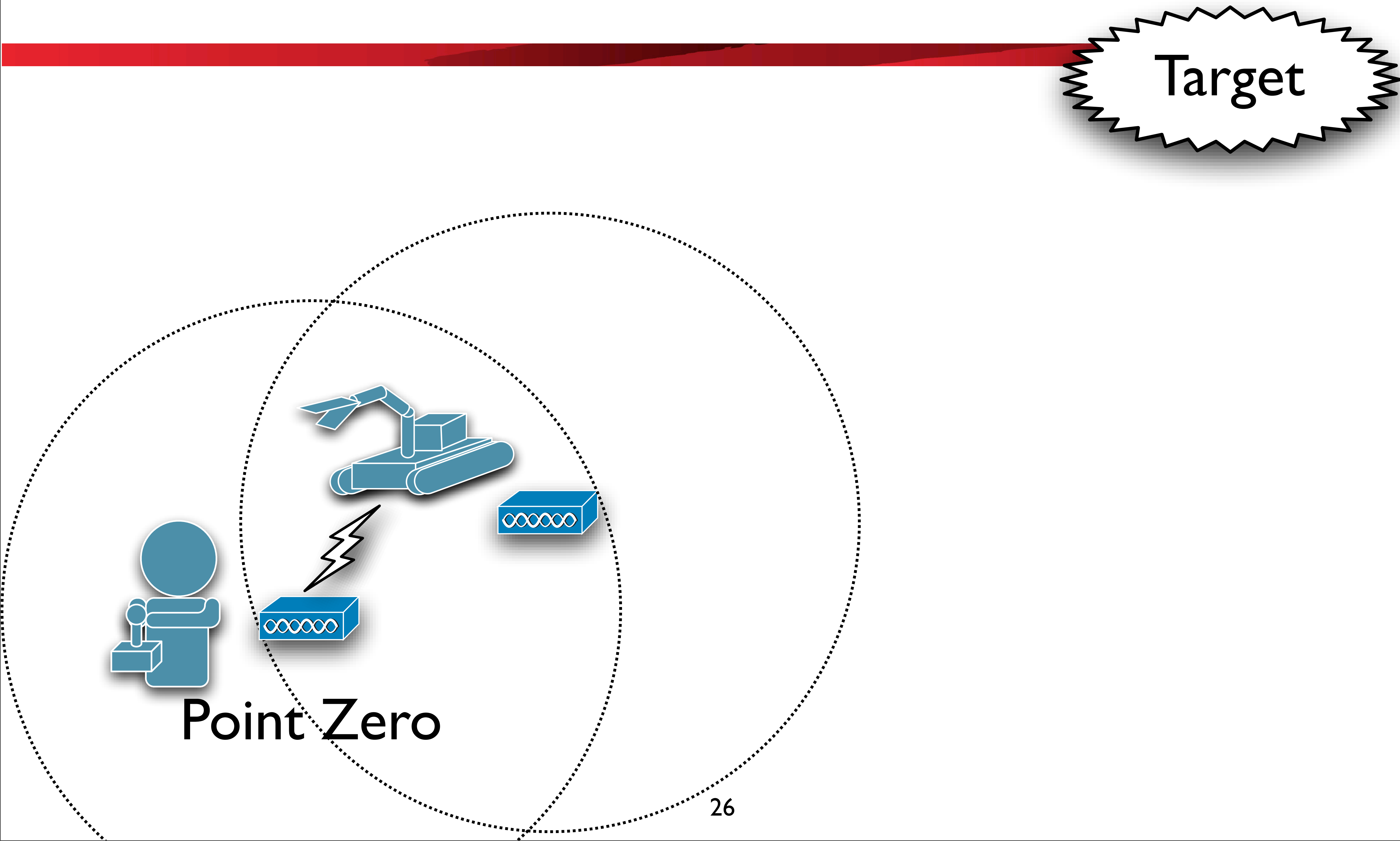
New Network designed for Rescue Activity

- Backbone is consists of multiple wireless IP routers
- Rescue robots will connect to the nearest wireless IP router
- A new wireless router is carried and located to extend the network itself

Operation Image



Operation Image



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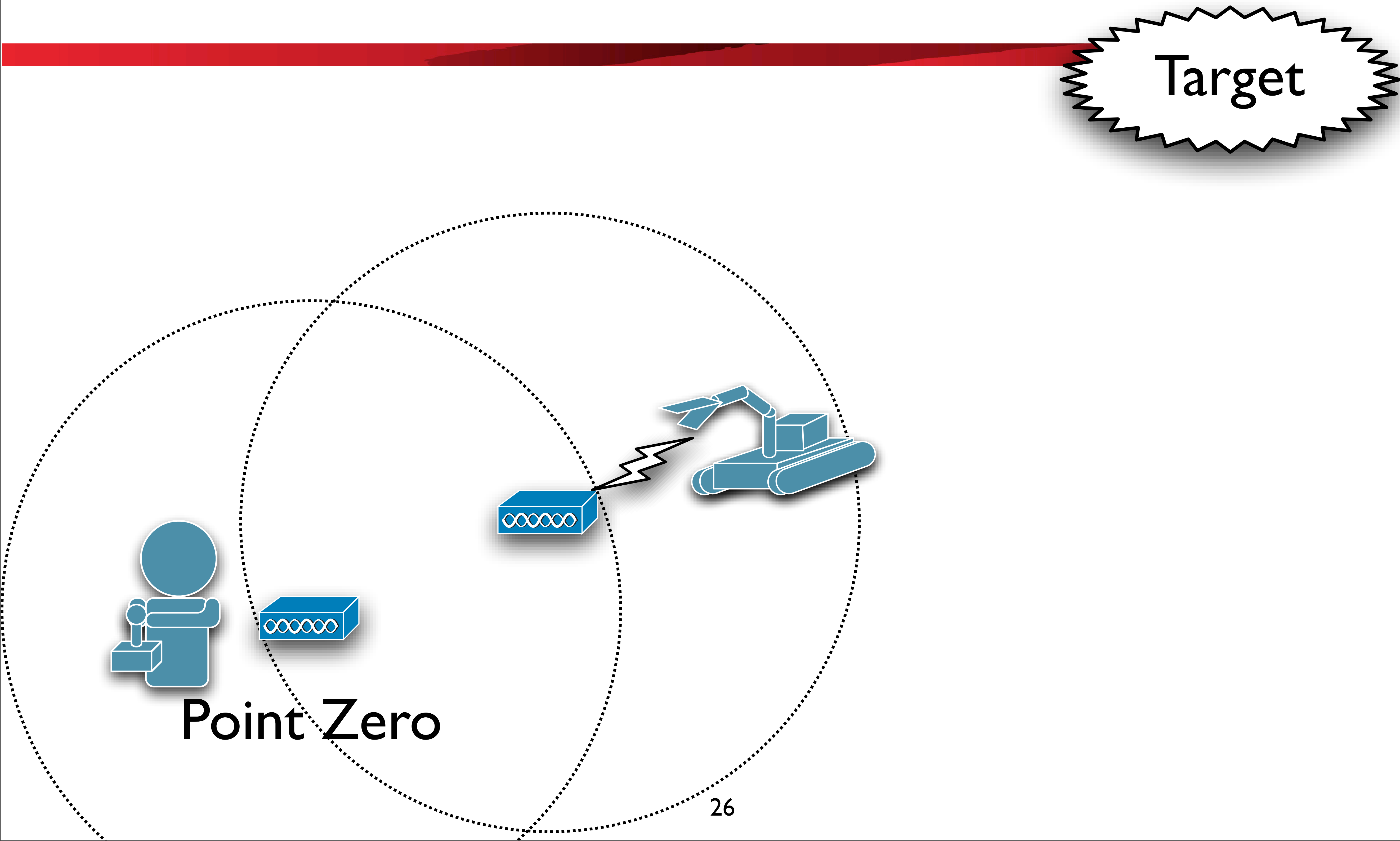

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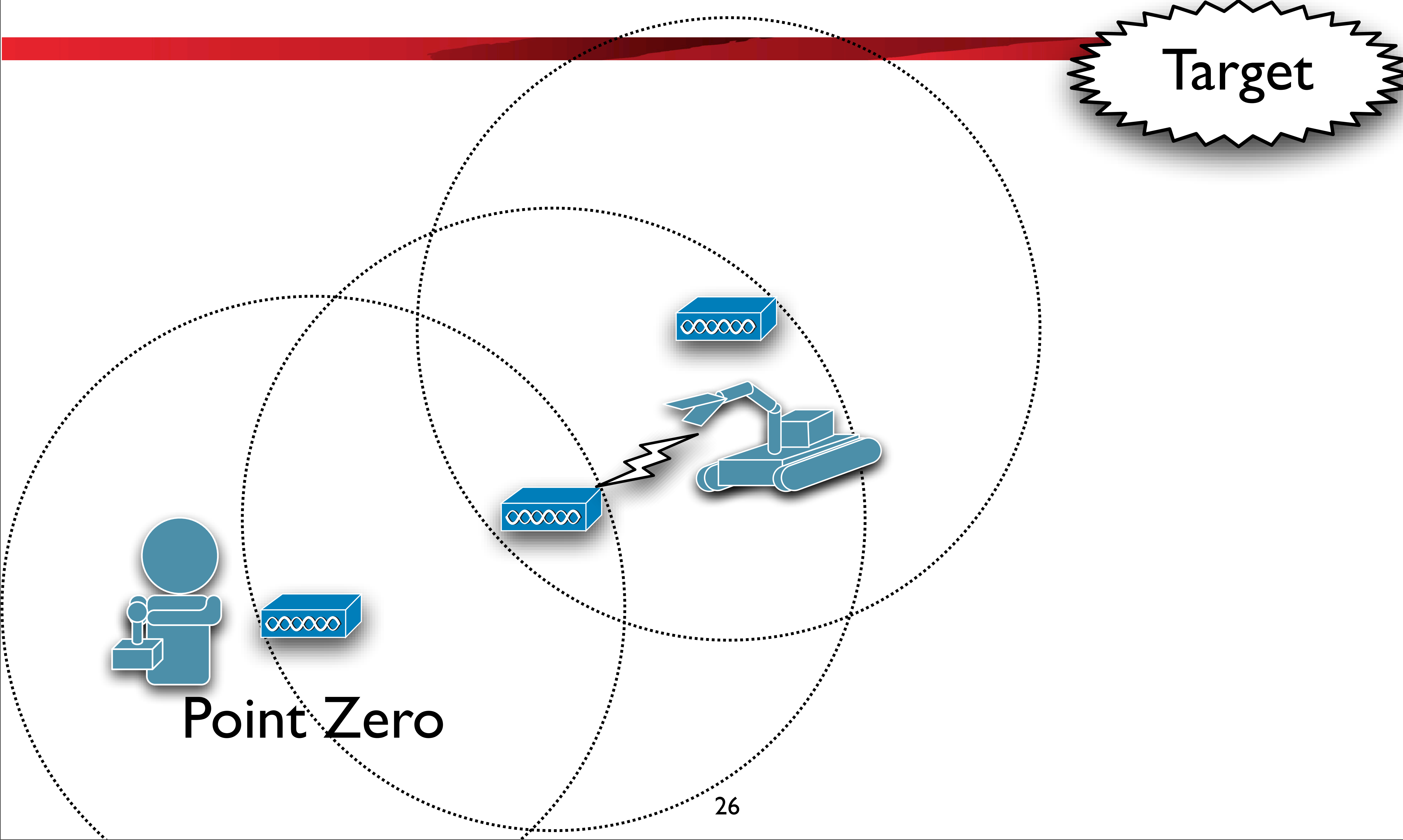

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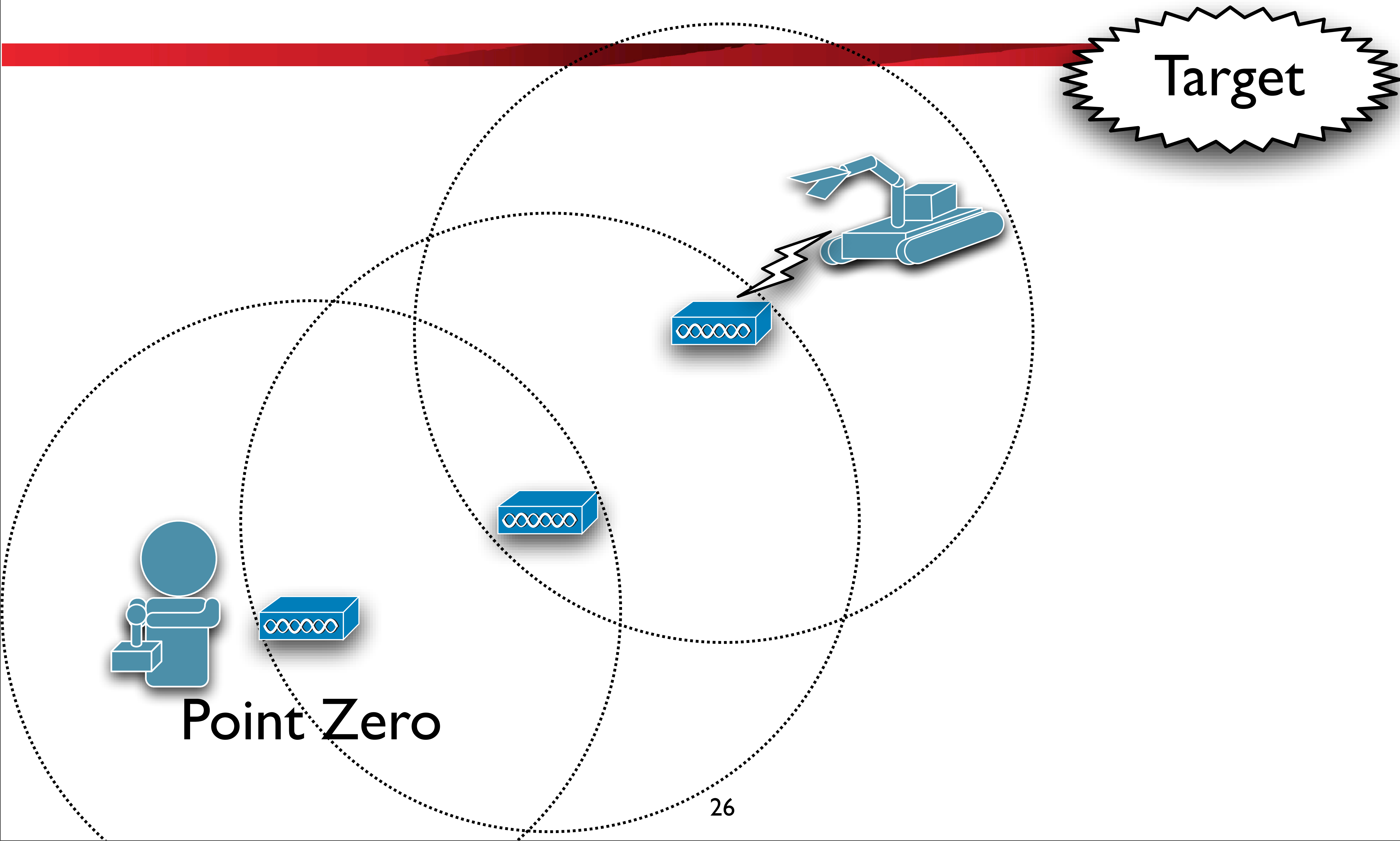

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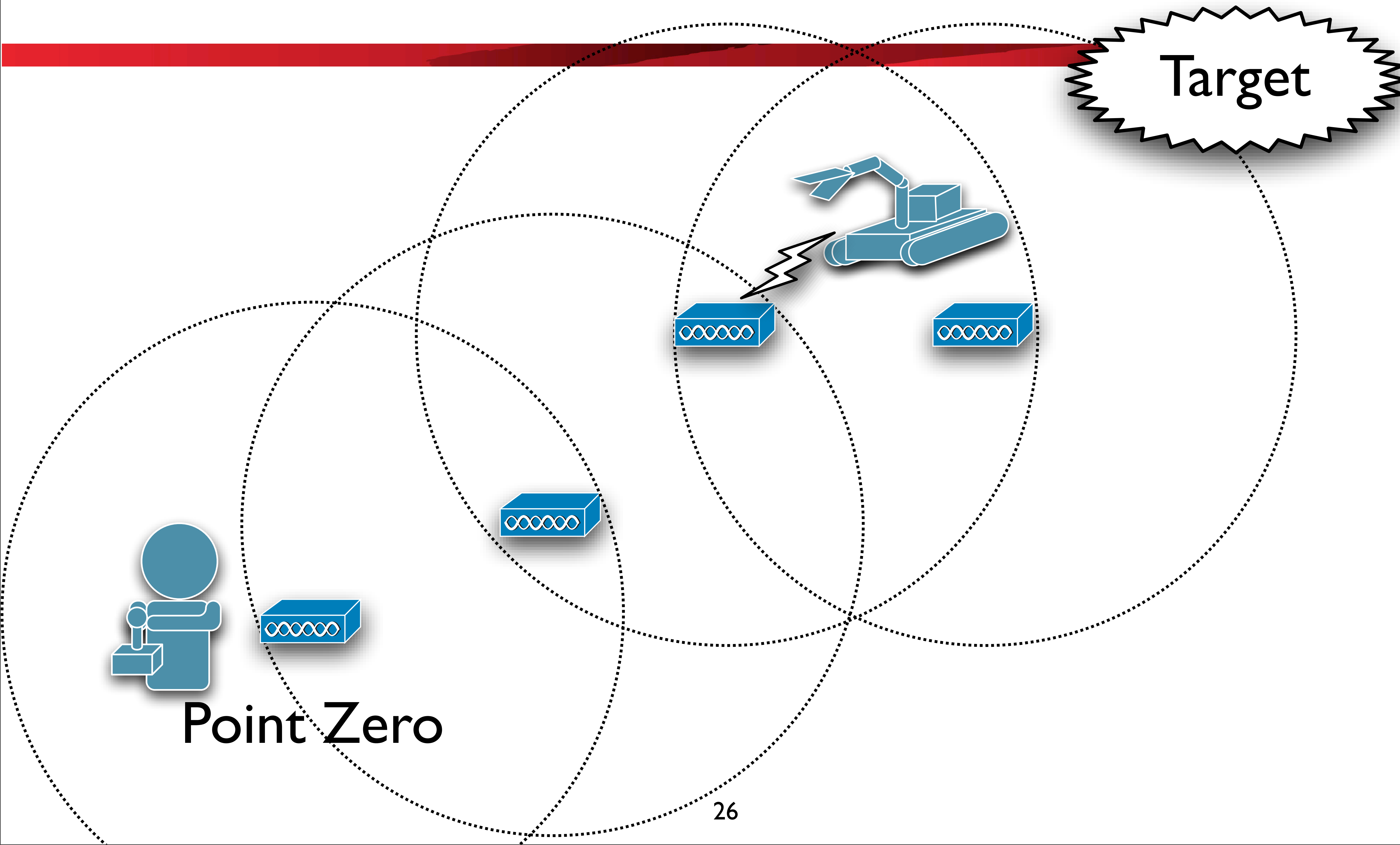

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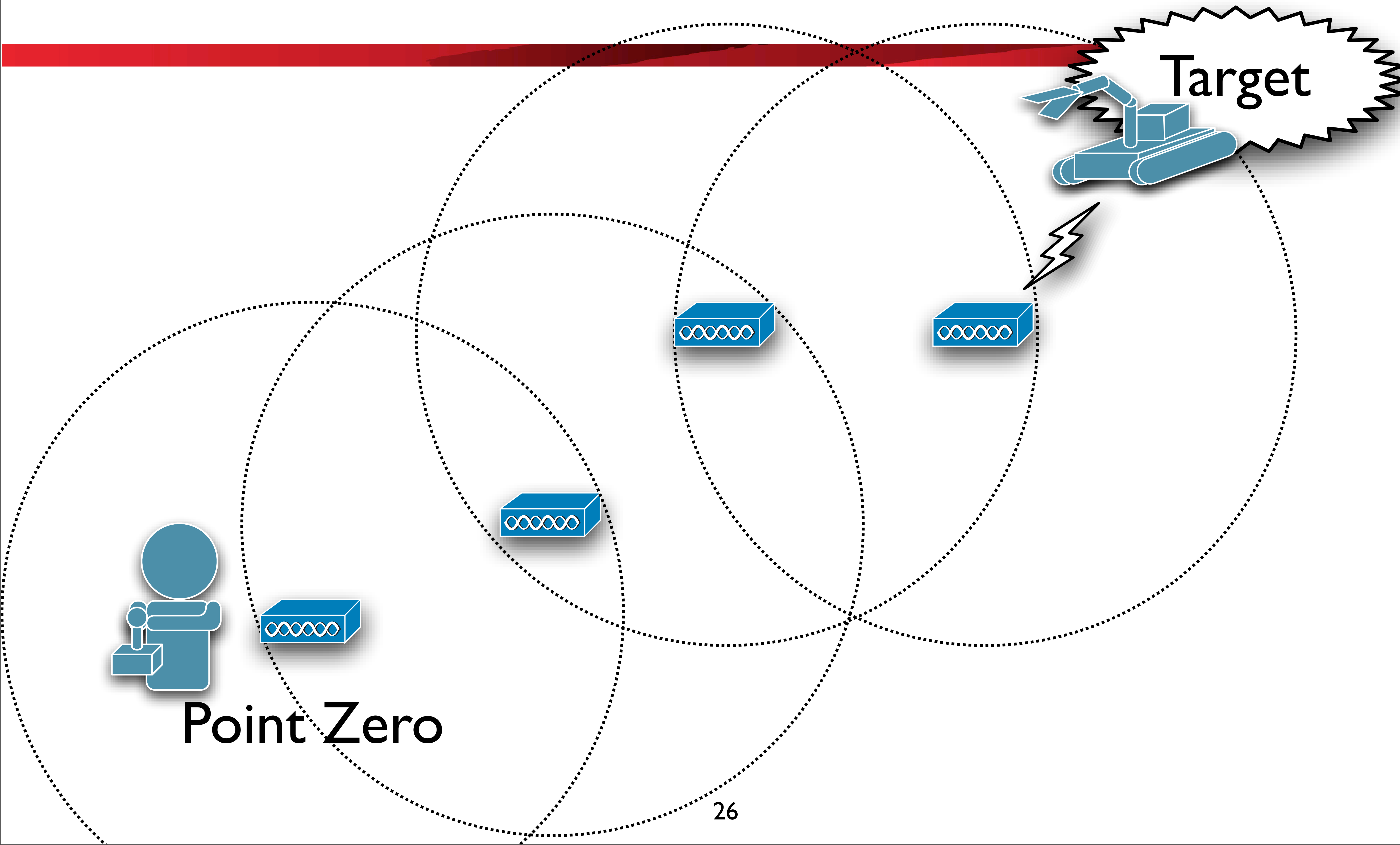

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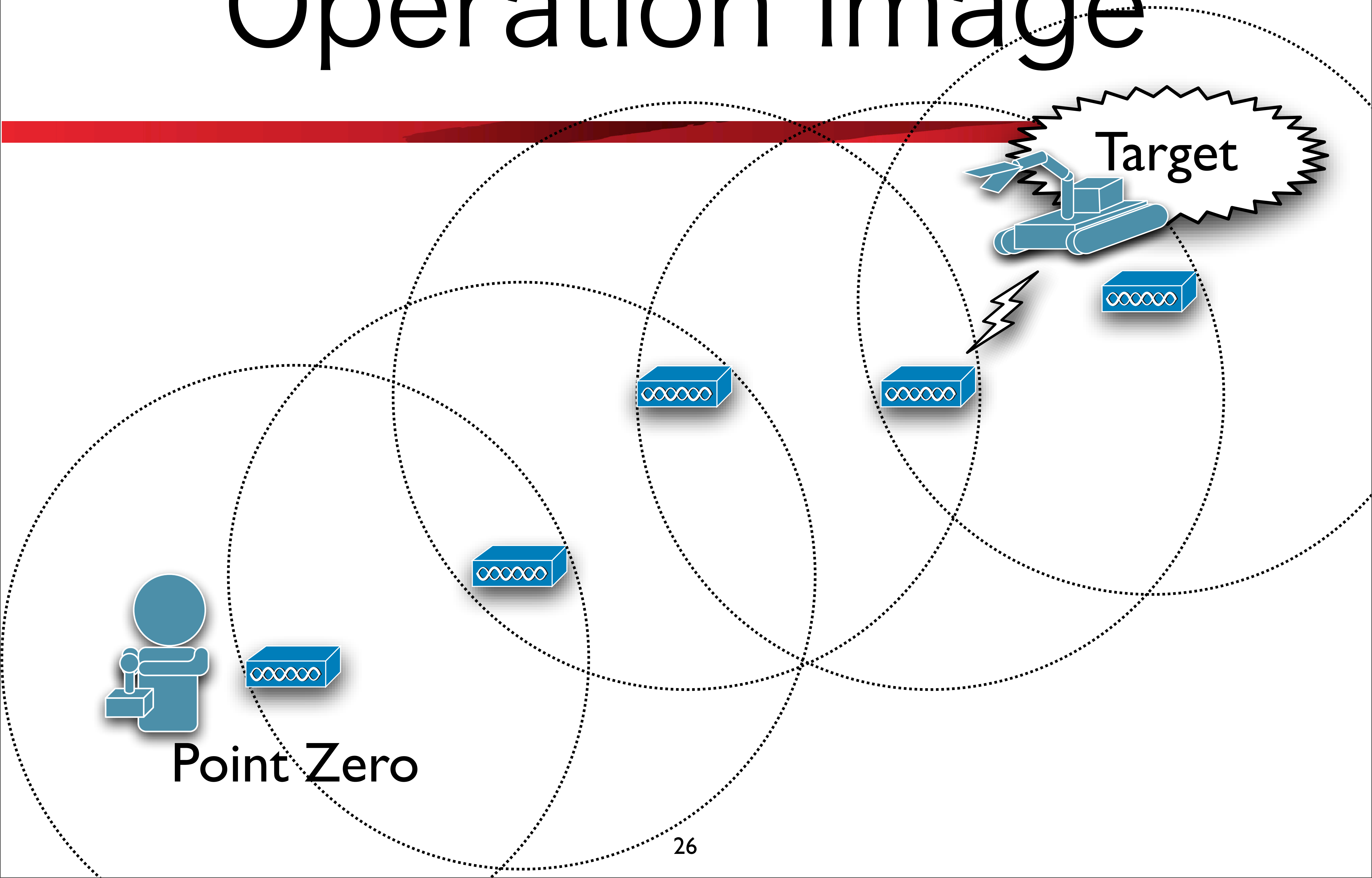


Requirements

- Automatic network construction
- Recovery from network failure
- Data type based communication
- Scalability

Data Type Based Communication

- Ad-hoc mesh network properties
  - Bandwidth changing time to time
  - Delay jitter
  - Unstable connectivity

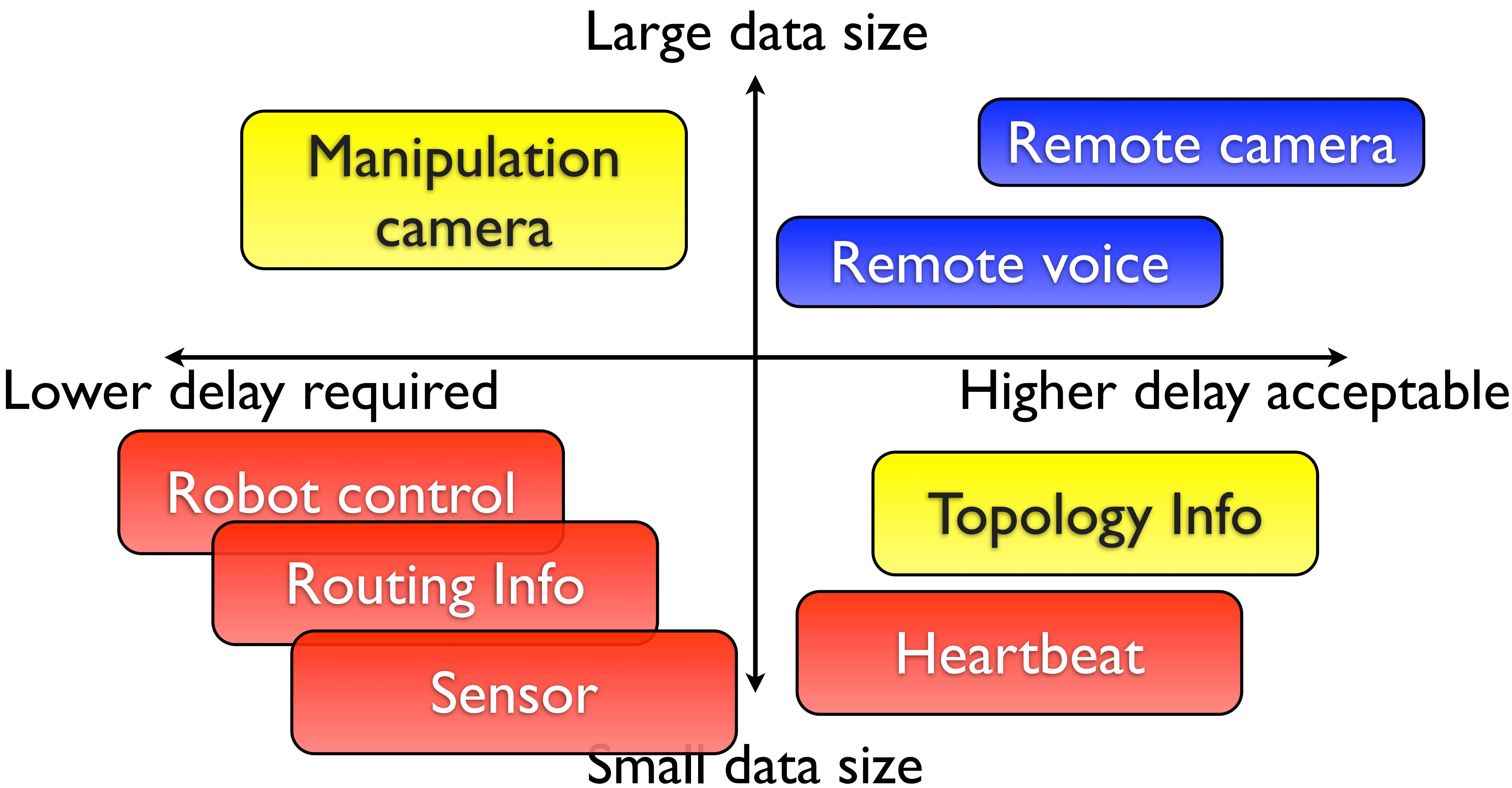
Data Types

- Data transmitted over the network
  - Network management data
  - Robot remote control data
  - Sensor, image data

Data Categories

- Size
- Acceptable delay time for each type
- Importance of data for each type

Data Categories



Selection of Data

- Ideally, all communication should be operable, however
- Data selection is required based on the environment
  - Sophisticated robot control
  - Network support

For Practical Networks

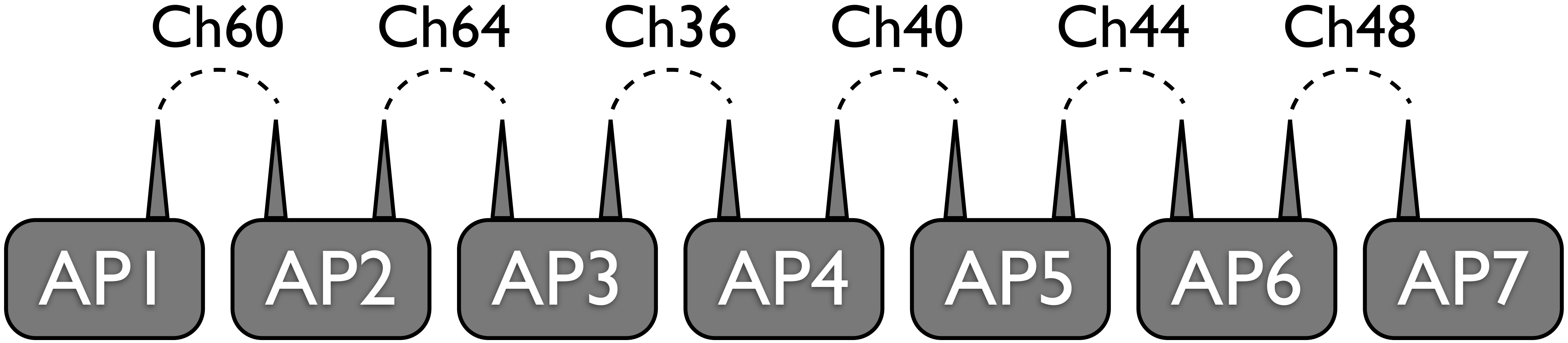
- Network technology doesn't solve all the problems
- Coordination with robotics technologies
- Enhancement of UI technologies

Networker's Approach

- As a part of the entire vision
  - Build APs with lower cost
  - Higher bandwidth
  - Manet based routing
  - Traffic control priority
  - Network as an application

Multihop Wireless

- Using cheap wireless technology (IEEE802.11) and IP



Multihop Wireless

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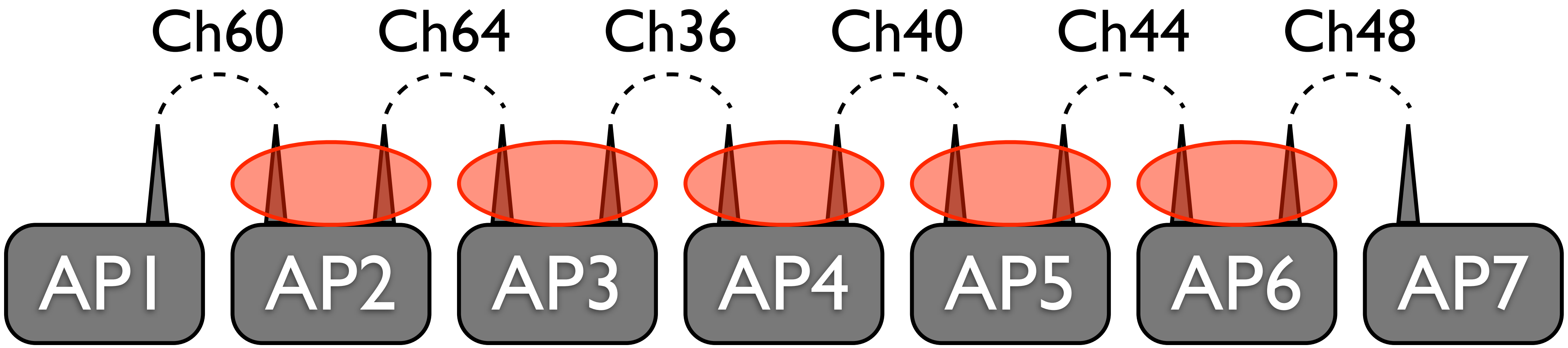
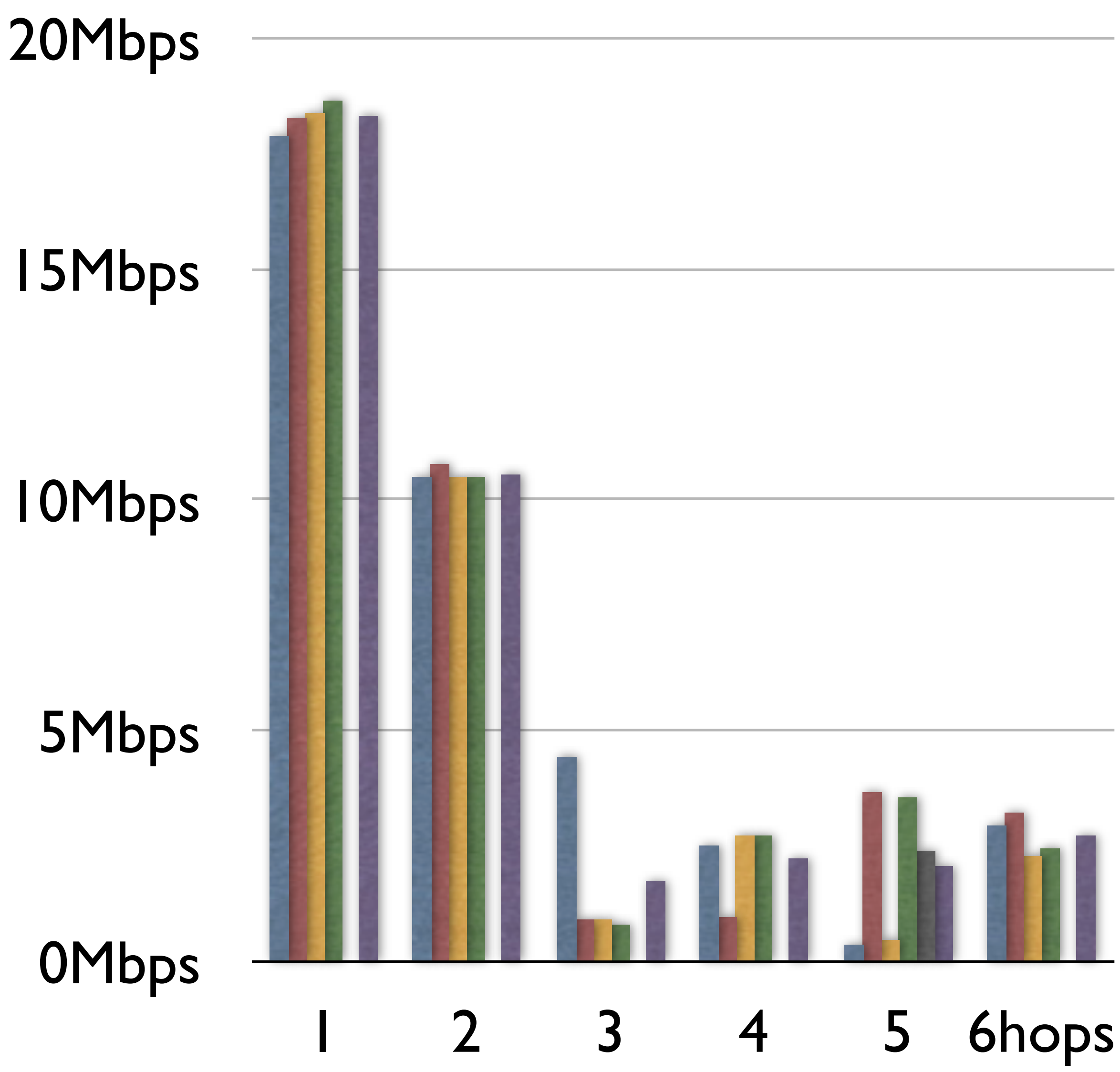


Terrible Results

- UDP performance measured by netperf
- At 6 hops, only one-fourth performance of 1 hop case could be achieved

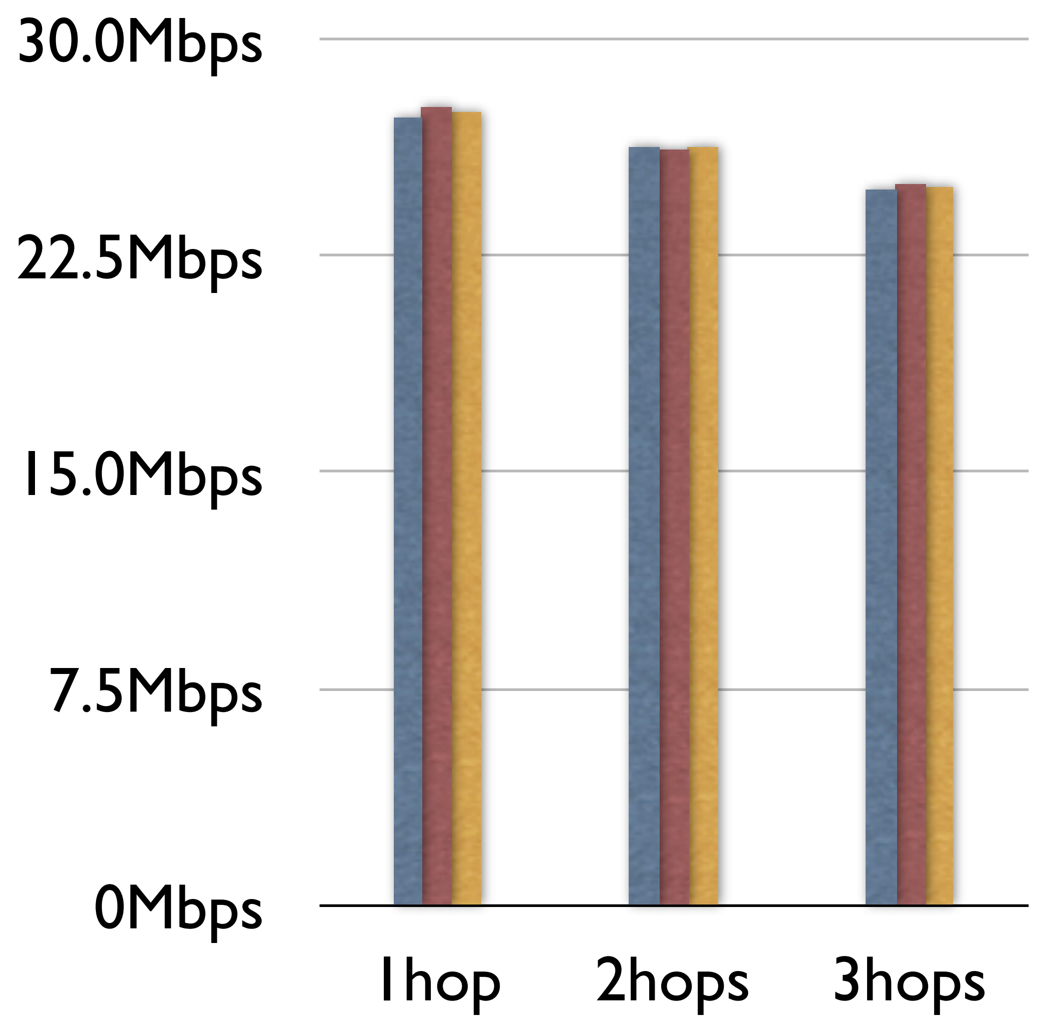


Interference

- Wireless module interfere each other even we use different channels
  - Direction antenna
  - Different bands

Mixture of Bands

- Direction antenna is hard to operate
- Using different bands on each link as much as possible
  - cf. “Routing in Multi-Radio, Multi-Hop Wireless Mesh Networks” by MSR

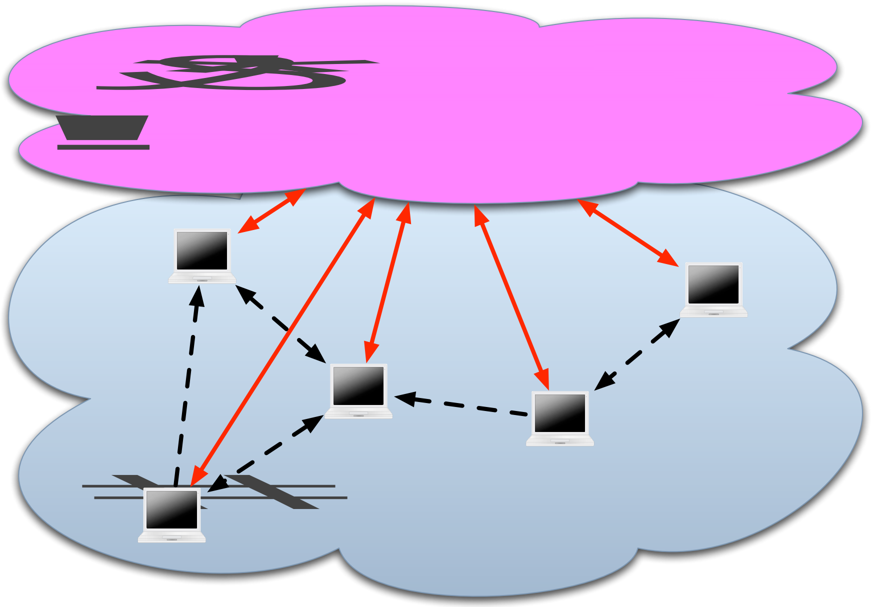


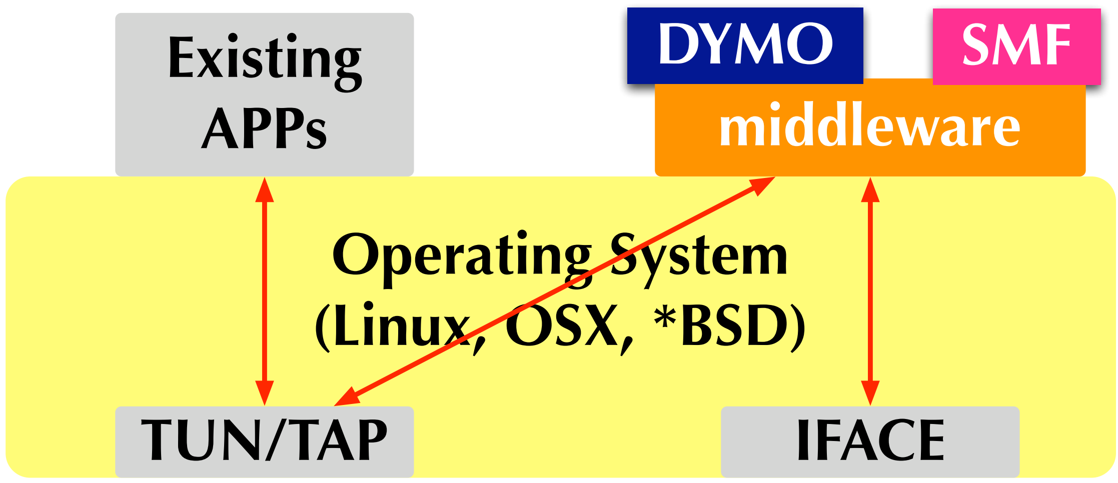
Overlay Manet

- Manet protocols sometimes depends the implementation design of layer 2
- Implement Manet protocol using overlay L3 network

Overlay Manet

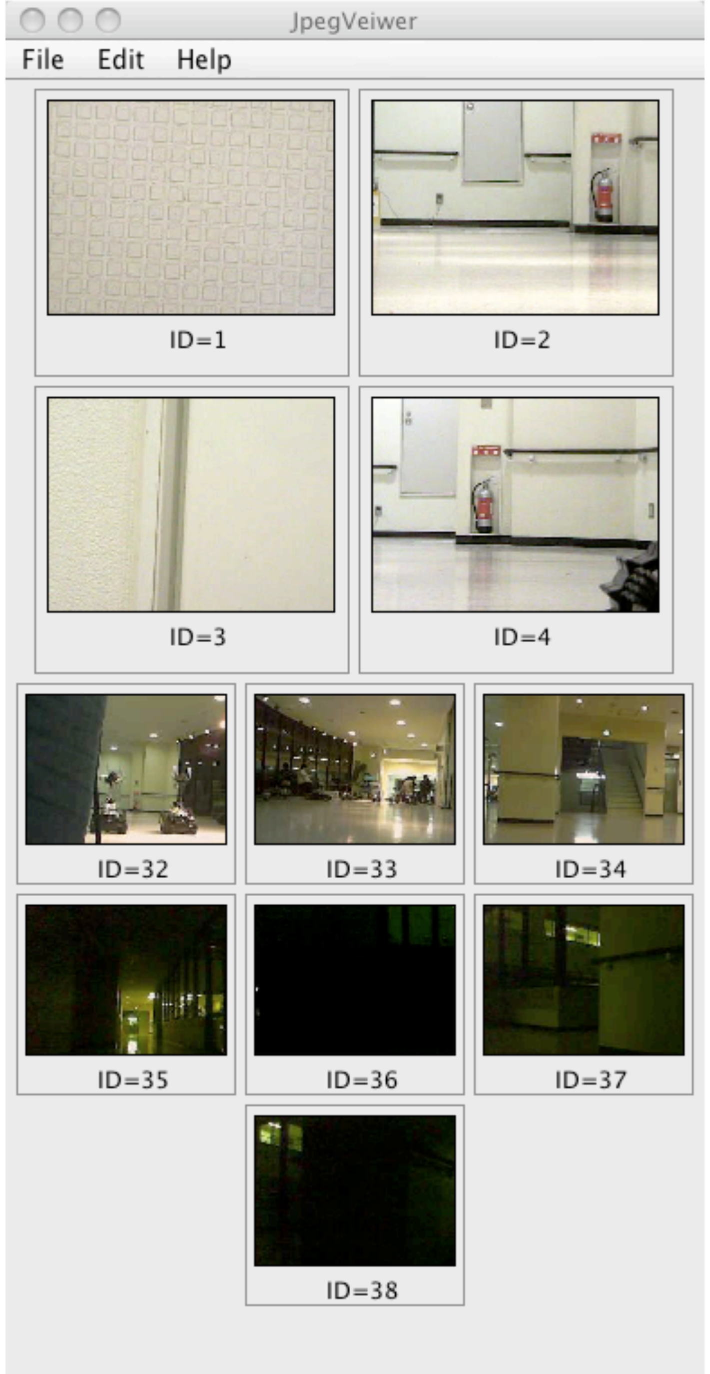
- Virtual Ethernet using tun/tap interface
- Manet protocols can be implemented over tun/tap interface, as if they are operated over Ethernet
- Detailed explanation by Sho FUJITA, Tadashi YASUMOTO

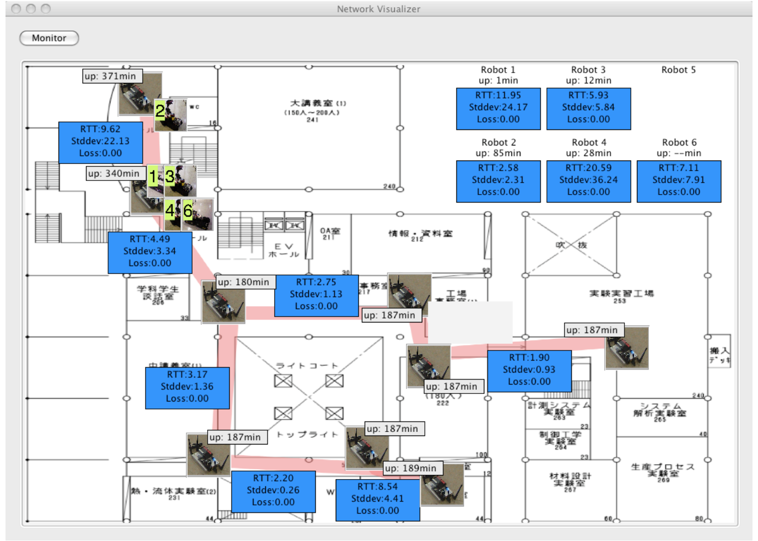


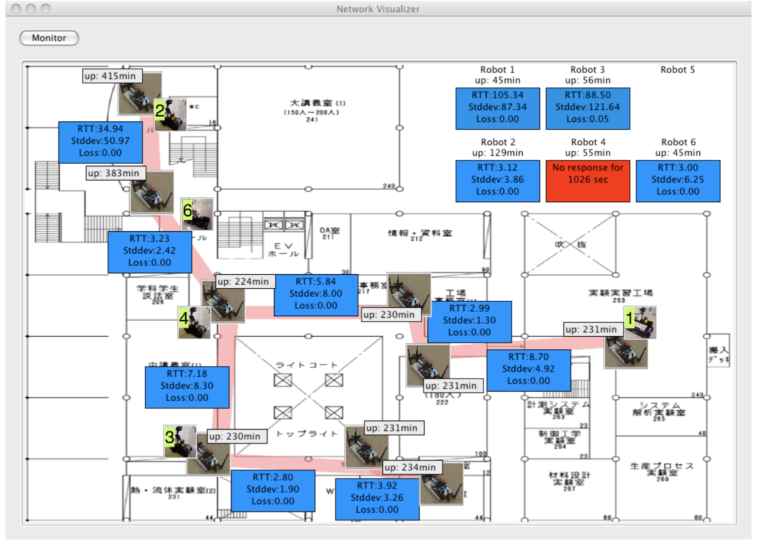


Network as Application

- Utilize the expanded network as an information infrastructure
  - Each AP sends snapshot image to robot operator
  - Each AP sends traffic measurement data to monitor application

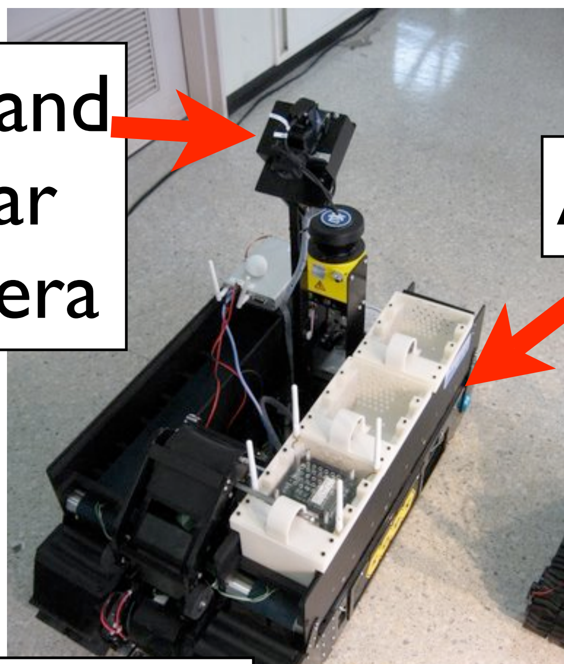


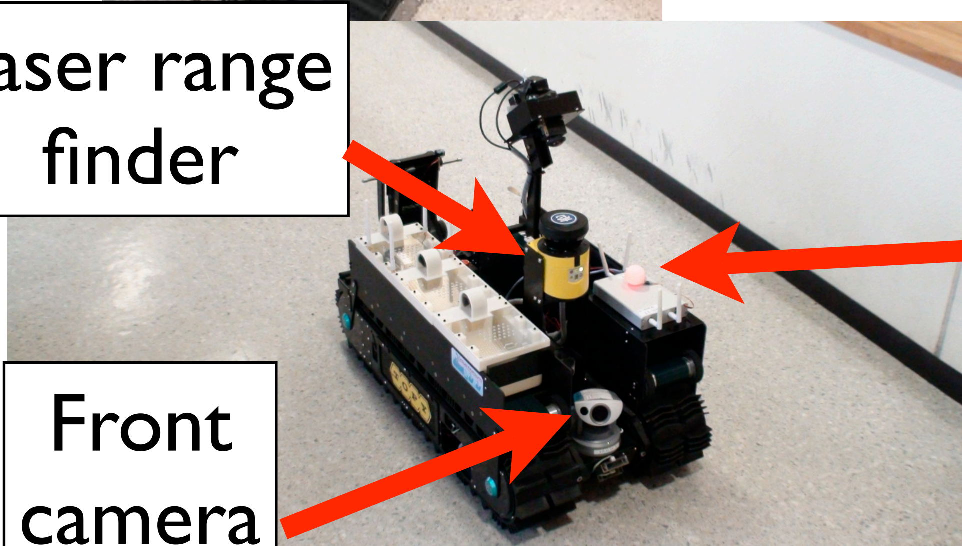




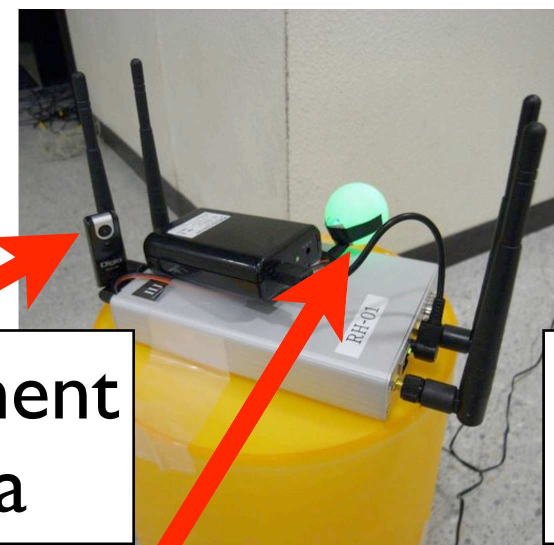
Network is just one part of the system

Robots

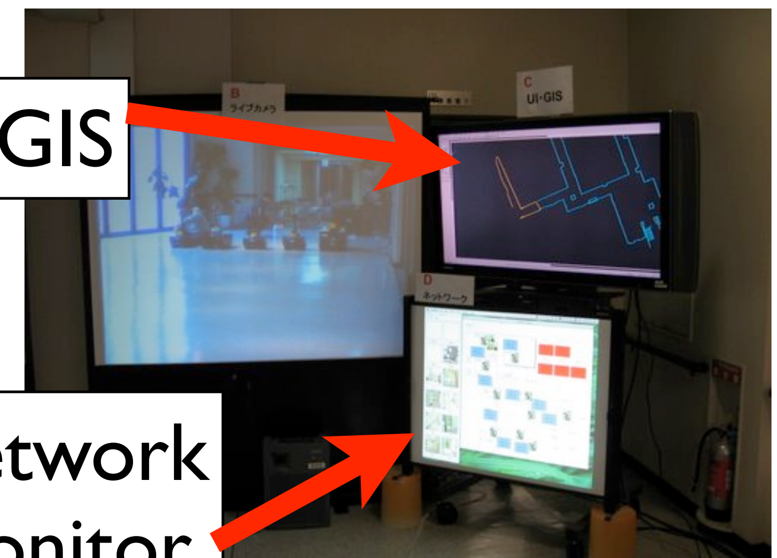




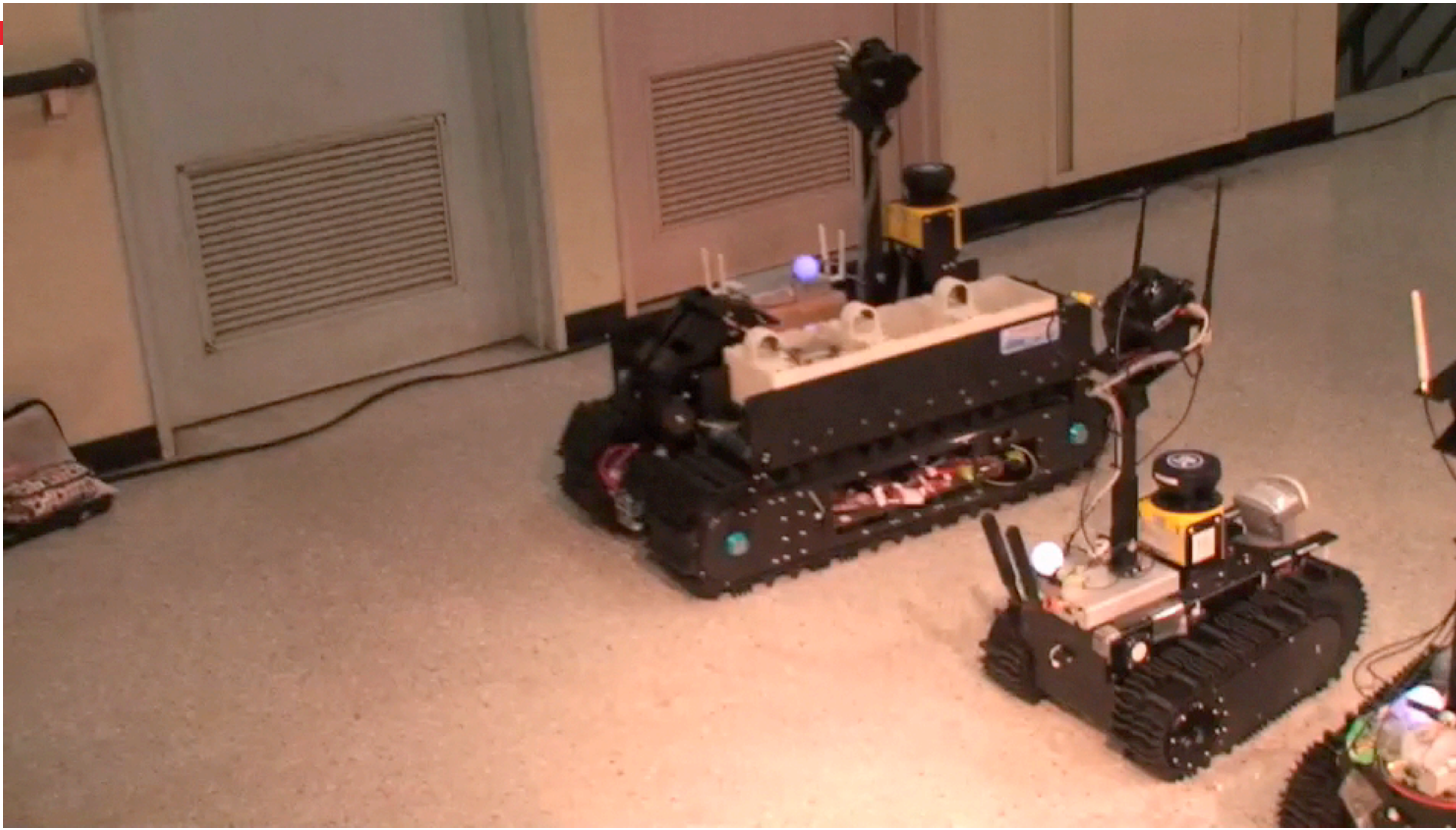
Access Points



User Interface



Video



Summary

- Infrastructure based layer 3 mobility technology completes its core parts
  - Next step is to establish the global scale operation technology
  - We are proposing such a mechanism and verifying it using our mobility infrastructure and with real neworks

Summary

- We have more frontier of mobility research and development
  - Infrastructure-less environment (e.g. disaster rescue)
  - Self-extensible network design and implementation
  - Network as an information application
  - Integration with other core activities